Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

eScience center

Integration of XIOS in the ECMWF weather model

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esiwace
CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

PRIMAVERA

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27/05/2019

Who we are

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

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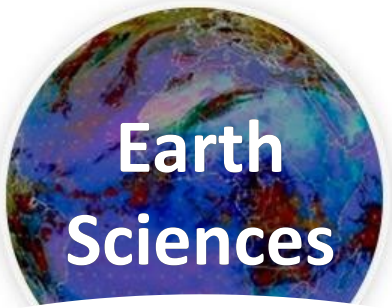
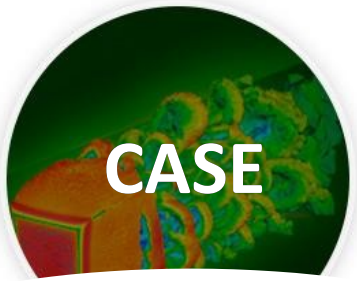
To influence the way machines are built, programmed and used: programming models, performance tools, Big Data, computer architecture, energy efficiency



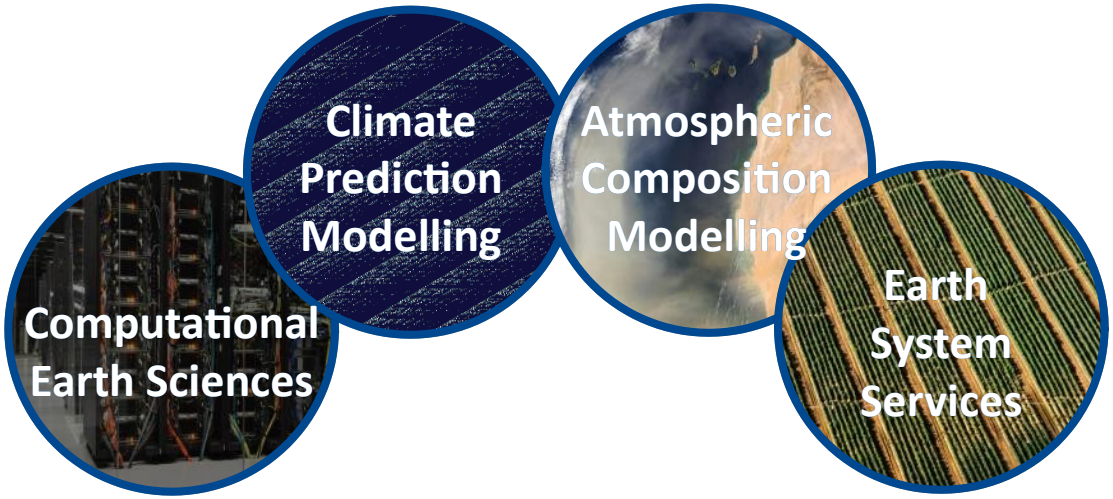
To develop and implement global and regional state-of-the-art models for short-term air quality forecast and long-term climate applications

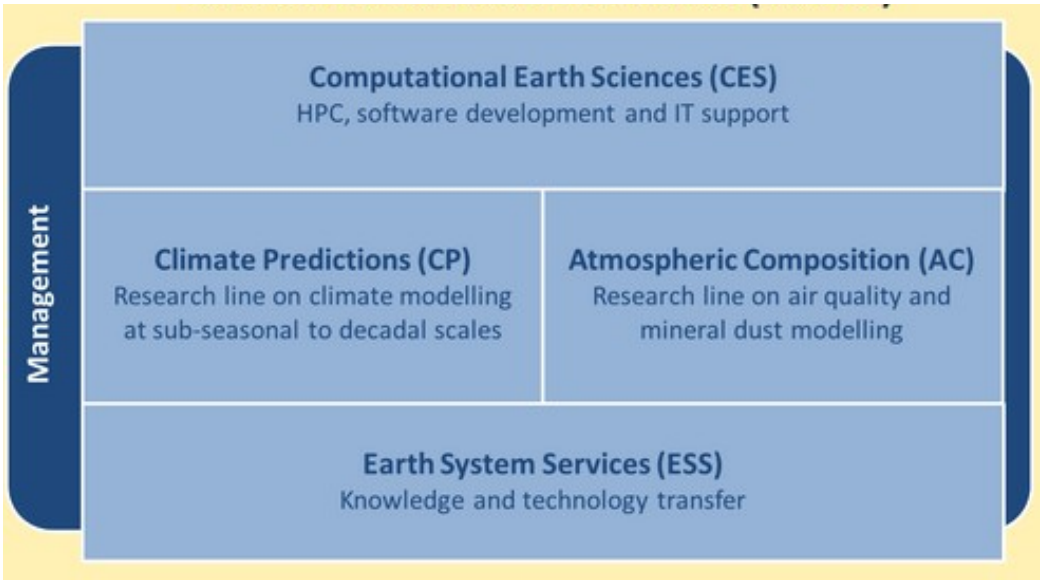
To understand living organisms by means of theoretical and computational methods (molecular modeling, genomics, proteomics)



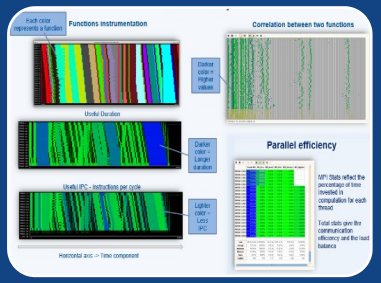
To develop scientific and engineering software to efficiently exploit super-computing capabilities (biomedical, geophysics, atmospheric, energy, social and economic simulations)

Earth Sciences Department



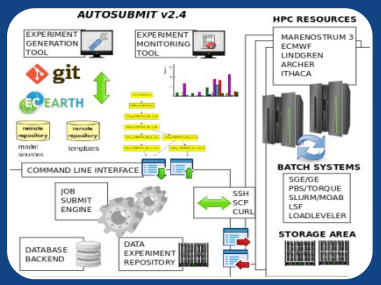


Computational Earth Sciences Group



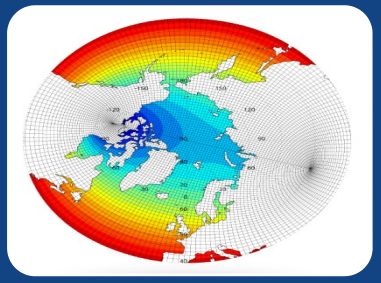
Performance Team

- Provide HPC Services (profiing, code audit, …)
- Apply new computational methods



Models and Workflows Team

- Development of HPC user-friendly software framework
- Support the development of atmospheric research software



Data and Diagnostics Team

- Big Data in Earth Sciences
- Provision of data services
- Visualization

Introduction

IFS overview

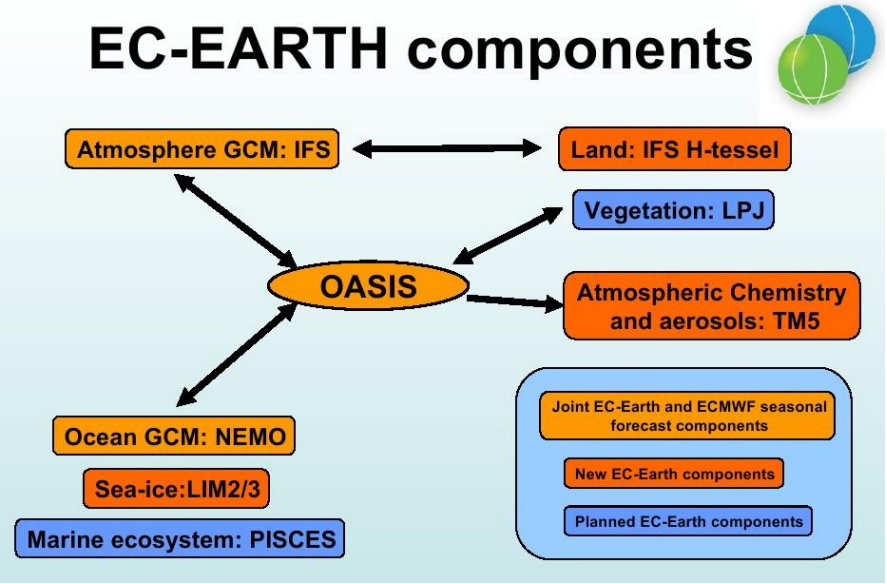
- The Integrated Forecast System (IFS) is a global data assimilation and forecasting system developed by the European Centre for Medium-Range Weather Forecasts (ECMWF)
- It writes using the GRIB format (standard in weather forecast
- It has two different output schemes:
  - The Météo-France (MF) I/O server which is fast and efficient from a computational point of view. It is only used at ECMWF, such its operational forecasts
  - A sequential I/O scheme which is slow and inefficient from a computational point of view. It is used by non-ECMWF users, this is, in OpenIFS and in the IFS version of EC-Earth

IFS overview

- The inefficient sequential I/O scheme of IFS requires a serial process:
  - Gather all data in the master process of the model
  - Then, the master process sequentially writes all data
- This is not scalable for higher grid resolutions, and even less, for future exascale machines

EC-Earth overview

- EC-Earth is a global coupled climate model, which integrates a number of component models in order to simulate the Earth system
- The two main components are IFS as the atmospheric model and NEMO as the ocean model



The I/O problem in EC-Earth

- In particular, the IFS version of EC-Earth is experiencing an I/O bottleneck
- EC-Earth has been recently used to run experiments using the T511L91-ORCA025L75 configuration under the H2020 PRIMAVERA project
- Experiments require to output a lot of fields, causing a considerable slowdown in the EC-Earth execution time
- I/O in IFS represents about 30% of the total execution time

Objective

- Taking advantage that NEMO is already outputting data through XIOS, we chose to integrate XIOS into IFS as well
- The use of XIOS has the objective of improving the computational performance and efficiency of IFS (by extension EC-Earth), and thus, reduce the execution time

XIOS

- The XML Input/Output Server (XIOS) is an asynchronous MPI parallel I/O server developed by the Institute Pierre Simon Laplace (IPSL)
- It writes using the netCDF format
- Written data is CMIP compliant
- It is able to post process data online to generate diagnostics

European collaboration

- Netherlands eScience Center (NLeSC) through Koninklijk Nederlands Meteorologisch Instituut (KNMI)
- ECMWF

IFS-XIOS integration overview

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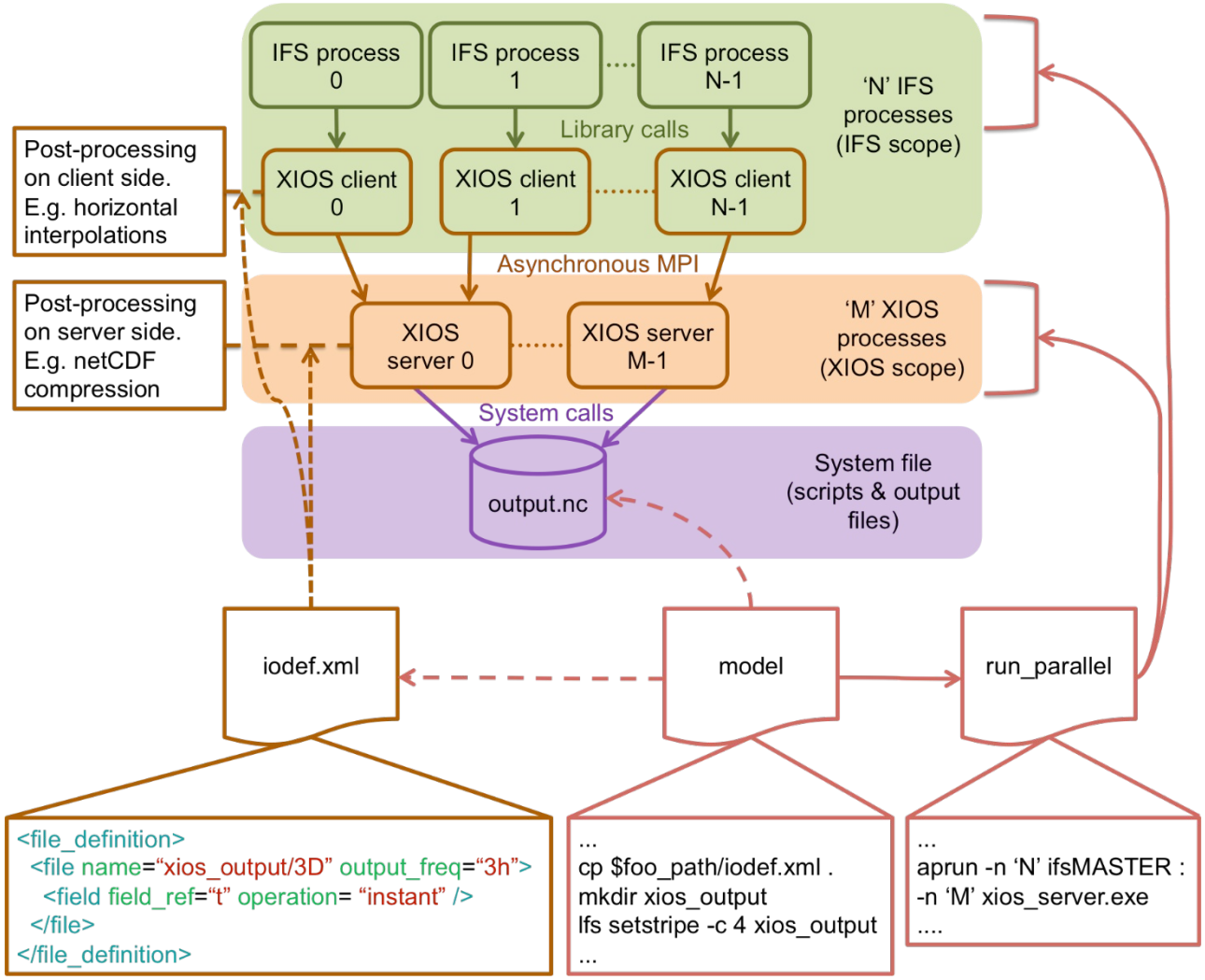
Scheme of the IFS-XIOS integration



Development done

A first complete version is already implemented:

- Both grid-point and spectral fields supported
- All 3D and surface fields
- Different vertical levels are available: model levels, pressure levels, theta levels and PV levels
- No longer needed to set up the FullPos namelist (NAMFPC)
- FullPos spectral fitting is available

Ongoing and future work

- Output data verification and testing
- Computational performance benchmarking
- Performance analysis and optimization
- Update XIOS 2.0 to 2.5
- Port the integration to OpenIFS 43r3

Optimization techniques

- Used:
  - Optimized compilation of XIOS with *-O3*
  - Scaling XIOS servers (# dedicated nodes and servers per node)
- To be evaluated:
  - Computation and communication overlap
  - Outputting in single precision
  - Parallelization using OpenMP threads of NPROMA reshuffle
  - Affinity tests of IFS processes and XIOS servers

Performance analysis example

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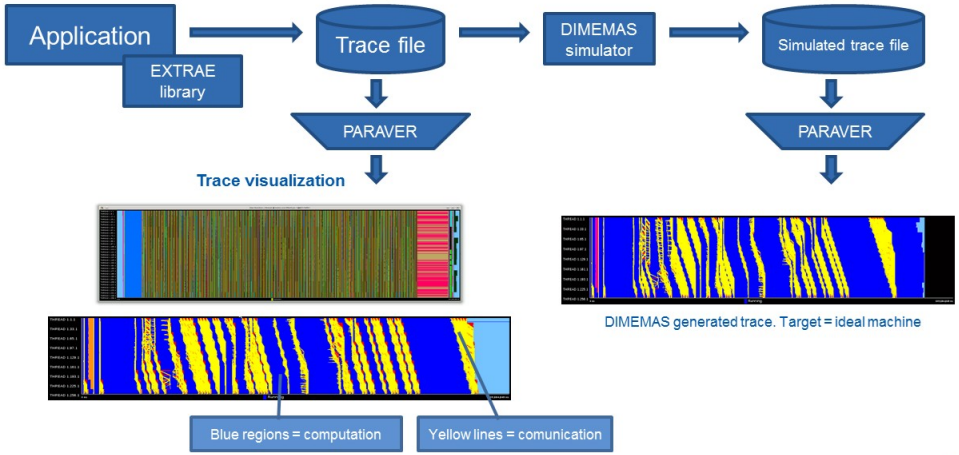
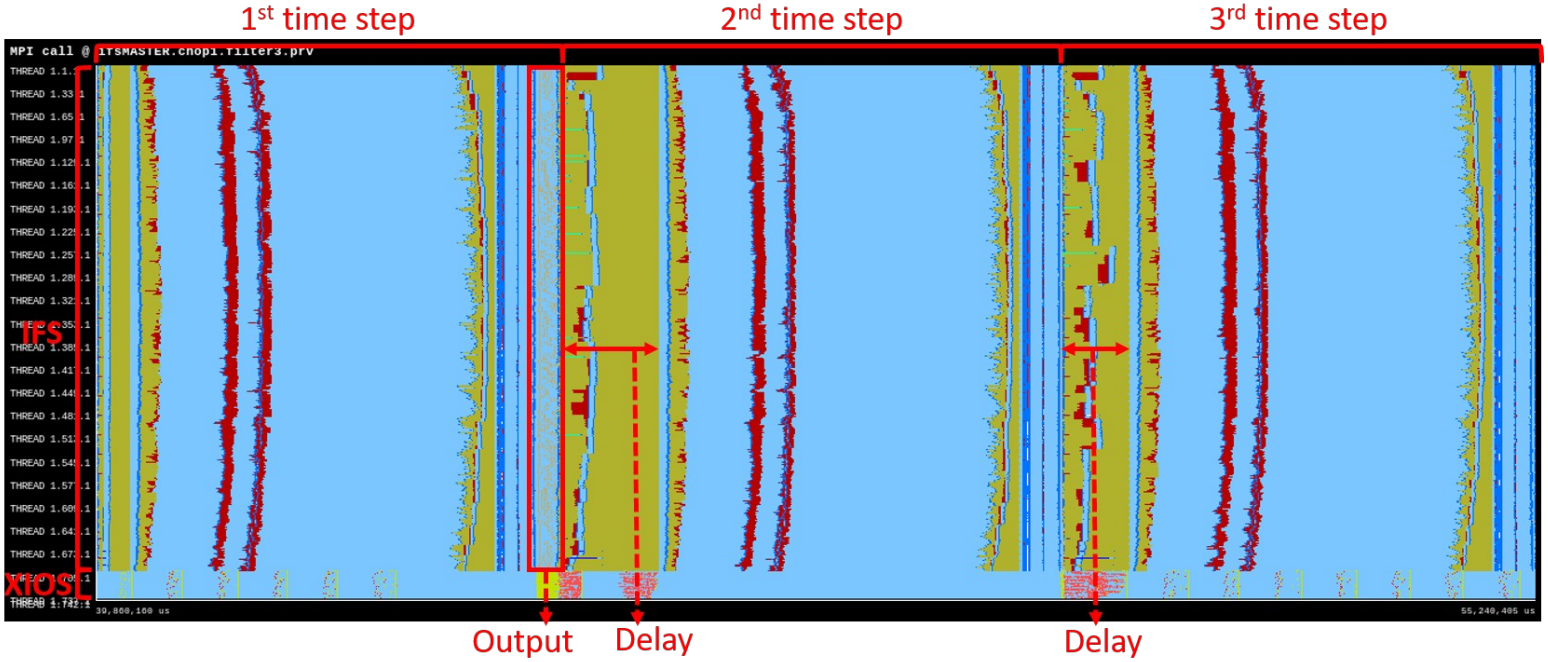
BSC tools

- Since 1991
- Based on traces
- Open source: https://tools.bsc.es/
- Extrae: package to generate Paraver trace-files for a post-mortem analysis
- Paraver: trace visualization and analysis browser
- Dimemas: message passing simulator



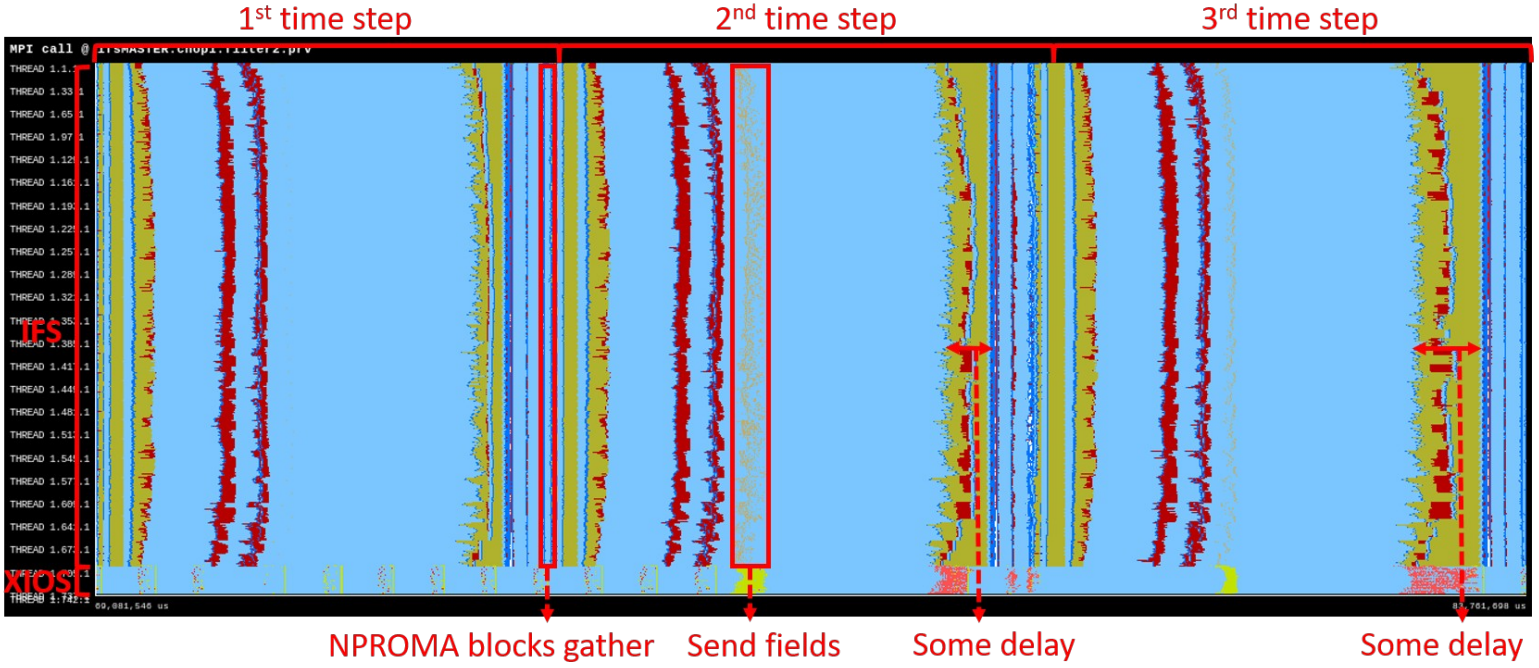
Computation and communication overlap

- The trace shows that after an output time step, there is a delay in the communications of the next two time steps (*MPI_Waitany* and *MPI_Alltoallv*)
- There is a conflict between intra IFS communications and IFS to XIOS communications



Computation and communication overlap

- The sending of data to XIOS is delayed to truly overlap computation and communication
- The trace shows that there is no delay at the beginning of the 2nd and 3rd time steps. However, there is some delay at the end, but it is less significant



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Thank you!

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